THE USE OF AIRPLANE PHOTOGRAPHS IN THE GEOLOGIC STUDY OF THE CHICHAGOF MINING DISTRICT, ALASKA*

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ABSTRACT: Multiple lens airplane photographs were used during the field season of 1939 in the geologic investigation and mapping of the Chichagof mining district, southeastern Alaska.

The photographs were valuable in the study of the physiographic features of the area, and to a limited extent, in the following of the boundaries between different types of rocks.

The principal use of the photographs was in the study of the structural features of the district, particularly the numerous faults that cut the bedrocks in a very complex manner. Valuable gold ore bodies lie in these faults and hence their mapping in as much detail as possible was desirable.

Many faults, whose surface expression is slight, would not have been recognized had the airplane photographs not been used.

INTRODUCTION

IN 1926 the Navy Department, in co-operation with the Interior Department, Geological Survey, and in 1929 in co-operation with the Geological Survey and the Forest Service of the Department of Agriculture, photographed from the air with multiple lens cameras more than half of southeastern Alaska's nearly 40,000 square miles. The picture scale is 1:20,000.

The photographs have been extensively used by the Geological Survey, the Forest Service, and other Government agencies. The Survey has published, mostly on a scale of 1:250,000, planimetric maps of much of the area flown. Considerable parts of the area have since been mapped topographically by standard planetable methods and the planimetric maps have been republished with contours.

When the photographic expeditions were planned one of the hopes held was that the pictures would eventually be of use in the study of geologic features The pictures were used to a limited extent by the author on Admiralty Island in 1937 and in the vicinity of the principal mines in the Chichagof district on Chichagof Island in 1938. During the 1939 field season, however, in the continuation of the work in the Chichagof district, the pictures were used extensively and systematically. It appears likely that the photographs will be of great value in future geologic work in southeastern Alaska.

It is with this latest use of the photographs and with its considerable value in the geologic investigations that this paper is principally concerned. The paper aims to show how the photographs were used and what sort of geologic information was obtained from them that, had the photographs not been used, either would not have been obtained at all or would have been obtained more slowly, with greater difficulty and less accuracy.

To provide a suitable base for the depiction of the geologic features of the district a topographic planetable map was made in 1938 by J. Mark Holmes of the Geological Survey. The publication scale of this map is 1:62,500 and the contour interval is 50 feet. In the making of this relatively detailed topographic map the earlier planimetric compilation made from the photographs was used.

Although discussions of neither the geography nor the general geology of the district are the principal purposes of this paper, short summaries of each are given in order to provide a background against which the use of the airplane photographs and the geologic results can better be described.

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Geography

The district lies on the western coast of Chichagof Island, one of the large islands of the Alexander Archipelago. Within the district a sea-cut coastal plain first appears above the ocean in a myriad of islands, large and small. The coastal plain attains an altitude of about 250 feet above sea level. From the meandering eastern limit of this plain the slopes rise steeply, even precipitously, to about 800 to 1,200 feet, between which altitudes are large remnants of another extensive erosion surface. From the higher surface just mentioned, rounded mountains and relatively flat areas are common to altitudes of between 2,500 and 3,000 feet. Above the latter altitudes are a few steep, frost-riven peaks and ridges. The highest peak in the district is 3,254 feet high.

The district is transected by several deep, U-shaped valleys. Some of the principal valleys for a mile or so near their mouths are narrow V-shaped canyons.

Timber line lies at about 1,000 feet. Below this altitude, except where slopes are too steep or the ground too poorly drained to support much vegetation, are dense growths of timber and brush. Above timber line the rounded surfaces make travel easy except in the very rough areas above 2,500 to 3,000 feet. A common obstacle to field work particularly above about 1,000 feet, is the clouds that frequently blanket the district down to about that altitude.

Geology

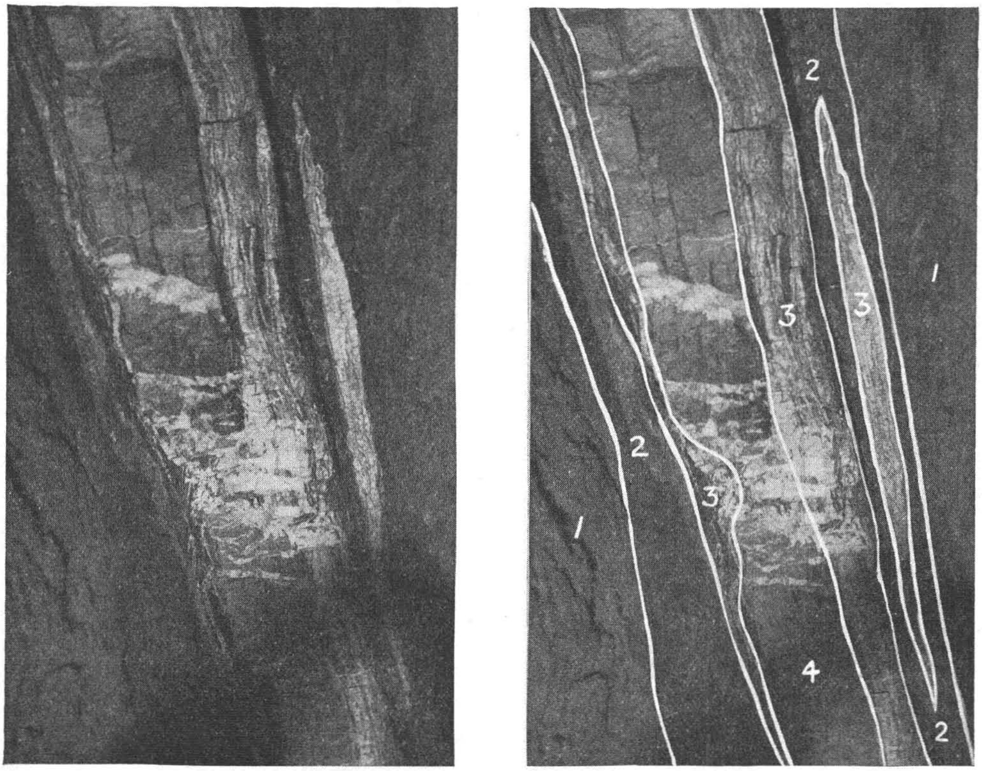
Most of the rocks of the district are stratified and were originally deposited in nearly horizontal layers. They are now steeply tilted so that the upturned edges trend northwesterly across the district. The tilt or dip is to the southwest and at most places is more than 60°. Both the dip and the strike of the rocks range widely at different places. At most places the traces of the bedding surfaces on the earth's surface are not very distinct.

The bedrocks have been broken along numerous faults by differential movements of the earth's crust. The faults in general trend northwesterly like the stratification and, also like the stratification, they dip toward the southwest. Locally the fault and stratification surfaces diverge widely from each other.

The faults curve and split in a complicated manner. Some faults are zones tens or hundreds of feet wide that extend for many miles. Others are very small and discontinuous. In fact, microscopic study of rock specimens shows that many faults of microscopic size are present. Between the wide fault zones and the tiny microscopic faults are all gradations. Therefore the faults to be shown on a geologic map are numbered only by the practical limits of recognition and location in the field and by plotting limits imposed by map scales.

The gold ore deposits of the district are quartz bodies that lie on or in the fault zones. The faults constituted the channels through which the quartz and gold-bearing solutions were able to penetrate the rocks. The locations and shapes of the ore deposits in the faults appear to be in large part controlled by warps or splits in the faults. The warps and splits in turn appear in large part to be controlled by the intersections between faults and stratification surfaces.

Light-colored, generally fine-grained dikes that have crystallized from molten material intruded into the country rocks from below are common in the Chichagof district. The interval of time during which the dikes were intruded was apparently a rather extended one. Many dikes are cut by faults, thus showing that the dikes were earlier than the faults. Other dikes were intruded into fault zones, showing that in these instances the faults were earlier than the dikes. Some dikes have been found in faults occupied by vein quartz and apparently were intruded after the vein quartz.



a b

1 foot (Approximate)

Fig. 1 (a) Photograph showing aplite dike in a fault zone. Vein quartz was deposited in the fault zone before the intrusion of the dike.

(b) Same as (a) but with geologic contacts added. Explanation: (1) Wall rocks of the fault zone. (2) Fault gouge. (3) Vein quartz. (4) Aplite dike.

Use of the Photographs

In considering the following discussion of the use of the airplane photographs the above sketch of the geology and geography of the district should be borne in mind as should the facts that a topographic map on a scale of 1:62,500 was available when the geologic mapping was done, and that the writer had a general picture of the principal geologic features of the district from the previous summer's work there, work which was principally underground in the two producing mines.

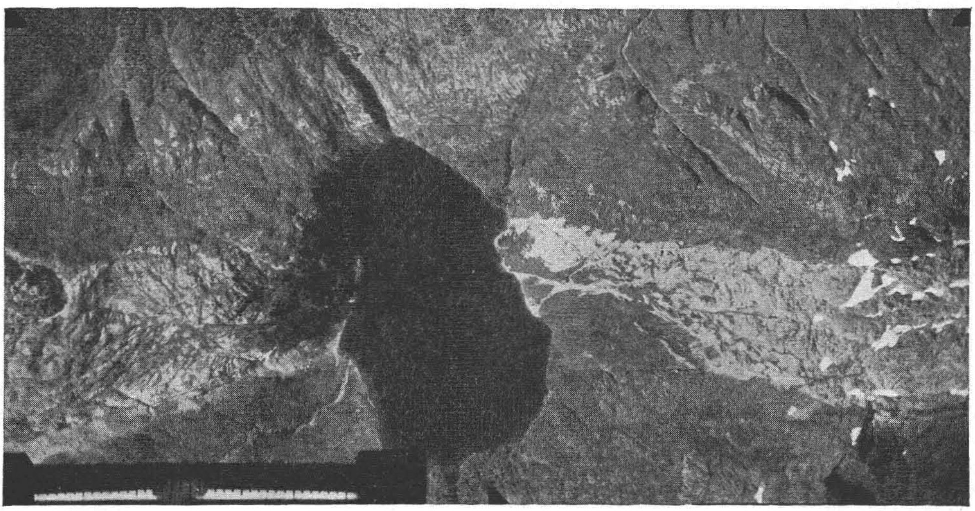
Locations

The photographs were of great help in spotting locations on the ground. A group of the pictures covering the area to be studied was carried into the field each day. Commonly such locations could be made more easily and more accurately on the photographs than on the map. This was largely due to the facts that the photographs approximate a 1:20,000 scale, whereas the map scale is 1:62,500, and that many features such as trees, tiny ponds, landslide scars, or distinctive rock outcrops were clearly recognizable on the photographs and on the ground, but could not be shown on the map because of the limitations imposed by scale and contour interval. Thus, while mapping, it became habitual to spot on the photographs the locations of places where geologic observations were made such as dips and strikes of stratification and of faults. These data were later transferred from the photographs to the contour map. In most instances any point spotted on the photographs could be transferred to the map, well within the limit of accuracy of the map, by simple inspection.

The photographs, particularly when viewed stereoscopically, proved to be of considerable value, along with the map, in picking out daily traverses to be made from boat or camp and in picking camp locations before they were to be occupied. An idea could commonly be gained not only as to where certain geologic features were to be seen but also how to reach them most easily. Considerable time was saved in the field by doing most of the stereoscopic work on the photographs during the many rainy and foggy days when outside work was impracticable.

Physiography

Physiographic features were found to be remarkably susceptible to stereoscopic study of the photographs. Much light was thrown by this means on such subjects as the depth to which an ice cap covered the district in Pleistocene time, the portions of the valleys that were recently occupied by alpine glaciers. and the limits and characteristics of the coastal plain.



1 mile (Approximate)

Fig. 2. Vertical airplane photograph showing band of light-colored marble in darker rocks in vicinity of Whitestripe Lake.

Areal Geology

The rocks of the district for the most part are difficult to distinguish from each other at a distance. Thus the pictures were of little value in determining the contacts or boundaries between different rock types. There were, however, several exceptions to the above generalization, the most notable being that both edges of a thick band of light-colored marble were visible on the photographs, in most places in considerable detail.

Granitic rocks occupy a considerable portion of the northeast part of the district. These rocks are intrusive into the older stratified rocks. Large parts of the granitic masses are somewhat soft and crumbly, apparently due to a combination of weathering and of rock alteration by solutions spreading upward from

1 mile (Approximate)

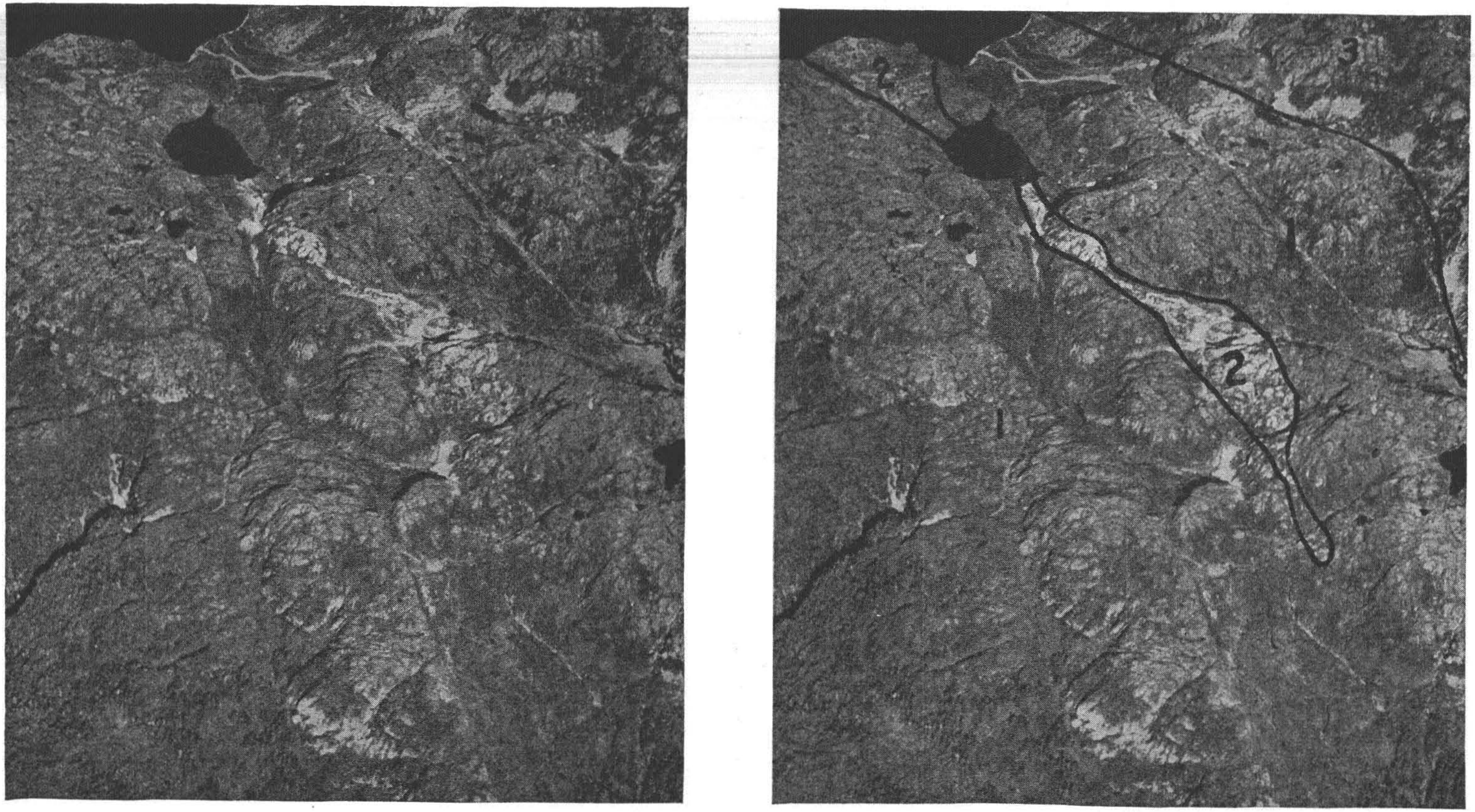
Fig. 3. Vertical airplane photograph showing dendritic drainage pattern in granitic area in northeast part of the Chichagof mining district. (Contrast with Fig. 4.)

depths. Because of certain conditions these granitic masses were not as intensely eroded by the ice during the glaciation of the district as were the surrounding areas. The altered rocks, since the ice receded from the district, were easily cut by the streams, and a dendritic drainage system has been developed. The part of the district occupied by such granitic rocks can be approximately delimited on the photographs by means of this distinctive drainage pattern.

It was found impossible, however, from the photographs alone to determine the boundary in great enough detail for publication on a 1:62,500 map. (Fig. 4)

1 mile (Approximate)

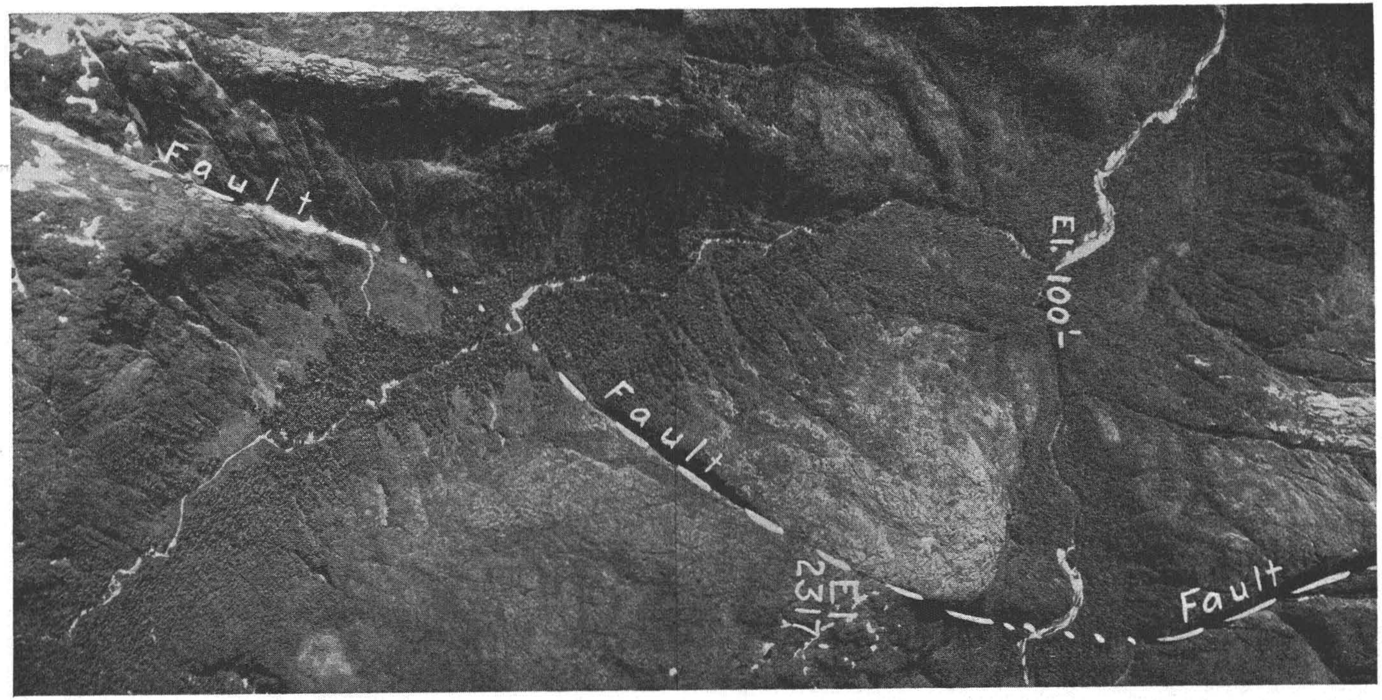
Fig. 4. Vertical airplane photograph of an area in the vicinity of Sister Lake, Chichagof mining district, showing drainage pattern developed on stratified rocks. (Contrast with Fig. 3.)



a b

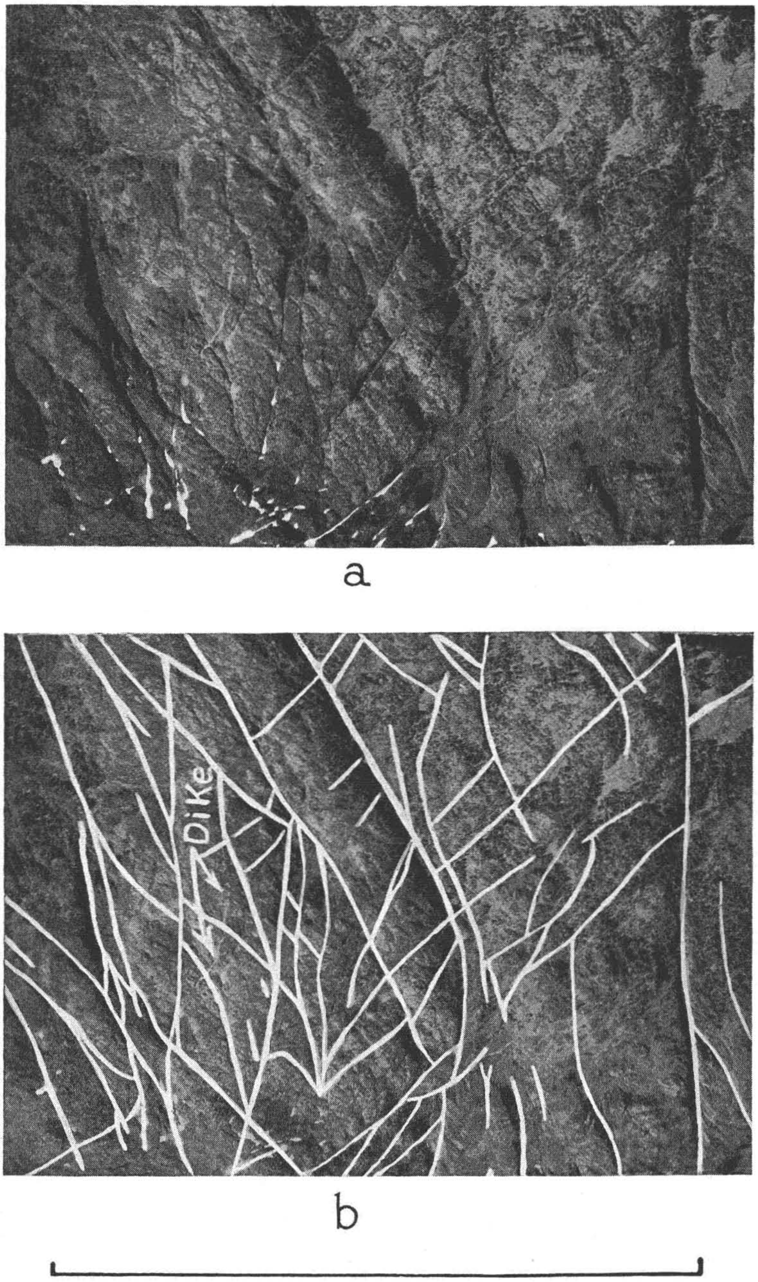
½ mile (Approximate)

Fig. 5. (a) Airplane photograph (untransformed) showing large aplite dike in stratified rocks in northern part of the Chichagof mining district.
(b) Same as (a) but with geologic contacts added.



½ mile (Approximate)

Fig. 6. Airplane photograph (untransformed) showing trace on surface of large fault in the vicinity of Hirst Mountain, Chichagof mining district.



1 mile (Approximate)

Fig. 7. (a) Airplane photograph showing traces on surface of faults in the southeast part of the Chichagof mining district.
(b) Same as (a) but with geologic features added.

Several of the light-colored dikes mentioned in the outline of the geology of the district are recognizable on the photographs. These are so inconspicuous in the pictures, however, that they generally were found on the ground first and on the photographs later. The photographs were nevertheless of distinct help in mapping the extent of these dikes. (See also Fig. 7.)

The mapping of the alluvial fill of rather flat-floored, densely timbered valleys, is a slow and difficult procedure. In the Chichagof district this was done easily, quickly, and more accurately than could have been done on the ground by drawing the contacts on the photographs as they were viewed stereoscopically.

Structural Geology

On the photographs of some parts of the district the strike of the stratification is readily distinguishable. Over most of the area, however, the vegetation cover is too thick, the edges of the stratification surfaces are too little etched out by erosion, or other differences between the various layers such as color and texture are too slight to be readily recognized on the photographs.

Faults

It is the study of the numerous faults of the district that the photographs have so far been of greatest value. Information from the pictures is permitting the recognition of faults and the plotting on the map of complex details that could be as effectively done in no other known manner.

The wide fault zones that continue for miles across and beyond the district would probably, for the most part at least, have been recognized and mapped even without the photographs. Such faults are strongly expressed at the surface and commonly are marked by depressions due to the greater ease with which erosion removes material from the soft fault zones. The large faults can be traced on the photographs with great ease.

Many of the faults of moderate surface expression and of probable moderate thickness and displacement were first recognized on the pictures and later were confirmed by observation on the ground. Most of these would probably have been overlooked had they not first been seen on the pictures.

Many other faults, mostly of weak surface expression, have been seen only on the photographs. They appear so similar to others that have been confirmed on the ground that they have been mapped with considerable confidence.

The known ore bodies, production from which to date aggregates some 16 million dollars worth of gold, are with a few very minor exceptions on one or the other of two of the many major faults of the district. Most of the ore bodies do not reach to the surface of the earth. There appears to be no geologic reason why similar valuable ore bodies should not lie in other of the major faults and these are considered as being well worth further prospecting. Thus, the economic importance of the recognition of the major faults is apparent.

Recent work in one of the mines has disclosed a rich ore shoot on a relatively minor split fault at a considerable distance from a major fault. The study and mapping of as much structural detail as possible is highly desirable, therefore, because other ore shoots may lie on other small faults on which there has apparently been but little relative displacement of the two walls. For such studies the airplane photographs are of great value.